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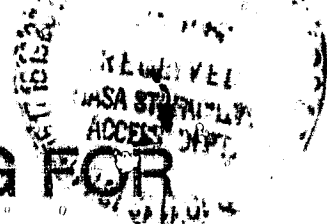
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USE OF REMOTE SENSING FOR LAND USE POLICY FORMULATION

Annual Progress Report, June 1, 1980-May 31, 1981

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Michigan State University
East Lansing, Michigan 48824

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ACKNOWLEDGEMENTS

The Michigan State University Center for Remote Sensing directorate wish to submit, with confidence and pride, our report of accomplishments achieved during the 1980-81 grant year. We judge our production to have been versatile, innovative and substantial, and of practical utility for agencies and firms throughout Michigan.

What has made these accomplishments possible has, again, been the continuing trust and encouragement with which our operations have been endowed through the continuing financial grants from the National Space and Aeronautics Administration through the Office of Space and Terrestrial Applications, Technology Transfer Division, University Applications Program, Joseph A. Vitale, Manager, under NASA grant number NGL 23-004-083.

The principals of the MSU-CRS acknowledge, with considerable gratitude, the continuing support of the MSU endeavors in the realm of remote sensing. From periodic comments brought to our attention, we feel reasonably confident that the cumulative accomplishments over the years realized as a result of the many associations between NASA and MSU, have been, in return, effectively supportive to relevant missions of NASA. We are encouraged by the continuing mutual high esteem shared by NASA officers and MSU remote sensing scientists, officials and collaborating organizations.

During this reporting year, June 1, 1980 to May 31, 1981, a considerable variety of research studies, contractual services and general service were carried on and completed. The accomplishments of these categories of activities described in the text material which follows were made possible by the cumulative synergism of the multi-disciplinary teamwork of faculty scientists, technicians and administrative staff members including personnel of collaborating agencies, with the substantial back-up of the NASA University Applications Program and Michigan State University administrative officers.

The long-term support of the MSU program continues to be the base-support for cumulative development of technical competence by the personnel of the Center for Remote Sensing and the progressive growth of esteem by the public-serving community of institutions for the achievements and demonstrated expertise of the Center's personnel.

In the light of the austere financial straits, operating agencies at all levels of business and government are increasingly having to cope with,

the continued support of NASA is proving to be an even more indispensable base of support for maintaining vitality and productivity of the MSU program.

Faculty Investigators

The following listing indicates those faculty scientists who were actively engaged in the productivity of the year being reported. There were many additional participants in CRS events and processes but the full citation of the Center's larger roster of participants who are involved in varying and changing intensities from year to year is not included here.

- + Jon Bartholic, Associate Director, Agricultural Experiment Station and Interim Coordinator, Center for Remote Sensing
- + Myles Boylan, Professor Emeritus, School of Urban Planning and Landscape Architecture and Principal Investigator, NASA Grant NGL 23-004-083
- + Dieter Brunnschweiler, Professor, Department of Geography
- + John Forsyth, Assistant Professor, Department of Computer Science
- + Stuart Gage, Associate Professor, Department of Entomology
- + Rene C. Hinojosa, Assistant Professor, School of Urban Planning and Landscape Architecture
- + Anil K. Jain, Associate Professor, Department of Computer Science
- + Delbert L. Mokma, Associate Professor, Department of Crop and Soil Sciences
- + Carl Ramm, Assistant Professor, Department of Forestry
- + Gene Safir, Associate Professor, Department of Botany and Plant Pathology
- + Ger Schultink, Research Associate, Department of Resource Development
- + Larry W. Tombaugh, Professor and Chairman, Department of Forestry

Center for Remote Sensing Research Staff

These following persons are the "technical staff" members who are referred to throughout this report. They consist of all non-faculty personnelnamely, full-time specialists (who count among the "Principals"), graduate research assistants and part-time student technical workers. These are the persons who carry forward most of the direction, operation and labor of the Center, carrying out the multiple tasks generated by faculty scientists,

collaborating and/or contractual agencies and all those seeking varying kinds and magnitudes of guidance and information.

- + John Baleja, Program Analyst
- + Elizabeth Bartels, Secretary
- + Valerie Cocking, Student Research Aide
- + Tom Colucci, Student Research Aide
- + Russ Dodson, Graduate Research Assistant
- + Mary Dugan, Student Research Aide
- + William R. Enslin, Research Specialist--Manager
- + Richard Hill-Rowley, Graduate Research Assistant
- + William D. Hudson, Research Specialist
- + Michael A. Karteris, Graduate Research Assistant
- + Kyle Kittleson, Graduate Research Assistant
- + Robin Landfear, Student Research Aide
- + David P. Lusch, Research Specialist
- + Saïid Mahjoory, Graduate Research Assistant
- + Scott Witter, Graduate Research Assistant
- + Andris Zusmanis, Student Research Aide

I N T R O D U C T I O N

The methods and capabilities of remote sensing technology are becoming increasingly expanded, more versatile, complex and sophisticated. No longer is a manual/visual interpretation of imagery followed by manual recording and simple quantitative and qualitative analysis anywhere near adequate for the increasing widespread demands for critical information. As these current years unfold, computer-assisted, digital interpretation, plotting and analysis of data from a variety of scanners on board aircraft and spacecraft commonly transmitting at frequent, regular intervals have become the minimum means.....the norm.....for serving informational needs about the condition and magnitudes of terrain and the cultural development upon it.

The Michigan State University Center for Remote Sensing principals have been working most diligently to acquire collateral funds to purchase the necessary basic equipment and software to enable this catch-up. As hardware equipment components have been acquired, integrated and made operational, faculty and staff have striven to develop capability in utilizing them for the needed effectiveness. In March 1981, the Center acquired the basic component of a micro-computer system with several basic software packages. As described in sections "C-2" and "C-3," under "General Missions," the staff through the 1980-81 period began the painstaking labor of installing, balancing out, integrating functions and components and otherwise making operational the beginnings of this system.

In the face of an intensifying demand for information, the economic shortfalls of the times have been progressively curtailing the fiscal capabilities of federal and state agencies, private firms, and the University to supply both direct funds for equipment acquisition and assembly and for contractual research which had been a growing, promising source for non-categorical funds which could sustain these kinds of essential tasks.

At the same time, these economic constraints have been influencing the nature of policies, legislative enactments, court decisions and agency/institutional priorities. The introductory commentary of the Progress Report submitted for 1979-80 is still highly apropos to the situation of 1980-81. A selected portion is loosely reiterated at this

point as a summation of the current challenges and opportunities open to remote sensing science:

"The increasing severity and austerity emanating from the current widespread economic shortfalls are influencing the nature of policies, legislative enactments and court decisions. Rationalizations are being offered for the lessening of environmental monitoring, controlling and enforcing. Expediencies are being substituted for careful deliberation and objective judgements. With such a trend in motion, it is all the more important to be able to counter impulsive, biased judgements with current, speedily-derived, accurate, irrefutable evidence of the condition of particular situations. Remote sensing, as one major means for obtaining such immediate information, should be supported in every possible way for continuing the flow of needed data and for sustaining further development of expertise.

"In parallel to this growing trend of lessened monitoring and controlling how resources are utilized, is the widespread, expanding capability for quickly detecting more instances and more kinds of environmental abuses and breakdowns. Governmental jurisdictions at all levels are becoming increasingly knowledgeable and capable.....even to sophisticated degrees.....to cope with new environmental disasters, negative impacts on human and wildlife health and for the ability to determine carrying capacities of different resource situations, together with knowledge of how to use technological tools and processes for resolving such issues.

"On the constructive side of the picture, public and private entities are learning to use elements of remote sensing techniques to improve husbandry, harvesting and marketing of food and fiber products; to locate new supplies of fiber and mineral resources; to monitor rates and volumes for harvesting, mining and disposal of waste products; to evaluate features of transportation systems (including pipelines and power line transmissions; to detect and calculate energy inefficiencies and to plan energy conservation programs; to monitor conversions of land cover and land use; etc.

"The key factor in staying effectively on top of this overall dynamic situation is the growing general capability for deriving essential, reliable information on short notice at affordable costs.

"Since 1971 the Michigan State University Center for Remote Sensing has been an important agent for advancing such capabilities in both private firms and public agencies in Michigan. To serve in this manner, the CRS has been a resource for imagery materials, technical assistance and training. This adjunct service role has been increasing over the last two years and possibly is becoming one of the Center's more important missions.

"The activities and achievements within this...reporting period demonstrate the versatility of the CRS in responding to

a substantial variety of needs throughout the state in addressing urgent problems and issues as well as broadening the using-capabilities of larger numbers of individuals and organizations. The increasing trend for cost-sharing by users on individual projects is another evidence of faith in the Center's competencies."

During this reporting year, a considerable variety of research studies, contractual services and informational services and training, equipment installation and refinement was carried out. As will be noted, the research studies were carried out with most costs incurred reimbursed by the NASA Grant budget, but in some instances, collaborating user agencies shared in reimbursing related costs. What are labelled this year as, "general mission" costs were, for the most part, also paid by the NASA Grant budget. "Contractual Services" direct costs, as implied by the term, were reimbursed in full by the client agency or firm; however, some indirect costs can be implied, such as those funds spent over the past for developing staff expertise, use of equipment and furnishings, heat, light and general administration. For these kinds of costs, a combination of NASA Grant and University funds could be considered as having contributed.

The five research studies described in this report under section "A," "Research Applications," were initiated and carried out by faculty scientists from University departments and some were conducted in partnership with various user agencies consisting of federal and state of Michigan departments and divisions, growers associations and cooperatives and University department and research agencies. The leadership participation of faculty scientists involved considerable expenditures of their time and energy which was paid for by the respective departmental budgets in terms of paying their salaries without any encumbrances on the NASA Grant funds.

Section "B," "Contractual Services," consisted of four separate studies carried out under contract with the user-client agency/firm which paid for all costs involved. The synoptic report for each describes the nature and scope of each and the amount of dollars contributed by the user-client.

The activities described under section "C," "General Missions Accomplished," consist of four kinds of engagements described in separate synopses. These were activities in training programs (short courses), the status quo of the digital processing micro-computer system with basic

software packages and provision of a variety of information functions to agencies, students and faculty and the general public. Of these four activities, the participants' fees in the short courses offset some of the direct costs in training programs.

Section "D" presents an up-date of the "informational summary" of quantitative information and is included herein as a supplement to the preceeding synopses. This special report contains selected categories of information originally requested by NASA and initially compiled by the Center principals, titled, "Project Information Report," and submitted September 22, 1978. This kind of report was instituted as a regular element for inclusion with subsequent progress reports. The data arrayed in this Section "D" have been organized under the same seven "categories" as were those in the original one.

Section A: R E S E A R C H A P P L I C A T I O N S

The research applications studies initiated and carried out during the June 1, 1980 to May 31, 1981 grant year consisted of the following five units:

- A-1: Evaluation of Landsat Data for Estimating Acreage of Small Forested Areas in the Southern Lower Peninsula of Michigan
- A-2: Application of Remote Sensing for Assessment of Damage to Small Grains Caused by the Cereal Leaf Beetle
- A-3: Remote Detection of X-Disease of Peach and Cherry Trees and of Fire Blight of Pear and Apple Trees
- A-4: Crop Area Estimation
- A-5: Delimiting Areas of Virus Infestation in Vineyards and Blueberry Fields of Southwestern and Western Michigan

Each of these five research application units is described in the synopses offered in this accompanying section.

The emphases this year, as it turned out, were three out of the five studies which dealt with crop stress and two with crop estimating techniques. Usually the research productivity of the MSU Center is more diverse in the kinds of categories; but as the reporting year ended, these five were up front as those which comprised the reportable research agenda.

Study A-1 was commissioned by the Forest Management Division of the State Department of Natural Resources (DNR) who provided \$6,000 for research to serve a multiplicity of purposes for the DNR and which served as the doctoral dissertation research objective for a graduate student on the CRS staff. This grant reimbursed at least direct costs. The sponsor agency judged this experiment based on Landsat-derived forest statistics a valuable supplement to current resources data.

Studies A-2 and A-3, investigating crop stresses caused by the cereal leaf beetle and by unidentified X-disease viruses, were initiated in the previous grant year but because of the limitations of growing seasons and the need to double check performance data for at least two growing periods, both had to be carried through into the 1980-81 research year.

The A-4 study, as a new undertaking, demonstrated reliability for vastly improving on standard methods of crop production estimation which

have been much too gross, with errors too high for acceptability and too costly to carry out, and, on the whole, too arbitrary for reliability.

Study A-5 was also a new research endeavor which was initiated during May 1981. The stress detection activities were carried on through the following five months for coverage of one full growing season and will likely be repeated into a second season for possible confirmation of tentative findings.

Although the functions of contractual services, general services and training may increase steadily to larger proportions of the Center's overall operations, the experimental research studies will always be the critical mass generating productivity. Through these experiences, the multiple capabilities and outreach of the Center grow and generate new methods, new domains of utility, more sophisticated processes and concepts. And through these kinds of investigations, the very optimum number and quality of scientists from university disciplines are drawn upon. It is from these kinds of innovative studies that other missions spin off.

First priority continues to be granted to the kinds of experimental research units which serve the objectives, missions and priorities of the University Application Program of the National Space and Aeronautics Administration.

A-1: Evaluation of Landsat Data for Estimating Acreage of Small Forested
Areas in the Southern Lower Peninsula of Michigan

Forest Management Division
Michigan Department of Natural Resources
P. O. Box 30028
Lansing, Michigan 48909

Grant: September 1979-September 1980
\$6,000

The Forest Management Division of the Michigan Department of Natural Resources (MDNR) needs a simple, inexpensive and reliable method for providing up-to-date county-level forest resources information. Presently, forest data are gathered periodically through the cooperative efforts of the MDNR, the U.S. Forest Service and the forest industry in Michigan. The major forest inventory of the entire state is the Michigan Forest Survey. However, the survey is conducted only every 10 to 15 years, it is not site-specific and it is statistically reliable only on a multi-county basis. The Forest Management Division is interested in whether accurate forest information on a county basis can be derived cost-effectively from Landsat data.

This demonstration study assessed the accuracy of mapping and estimating the area of scattered forestlands in southwestern Michigan from Landsat imagery. Scattered small forestlands were of interest because the ratio of their perimeter length to areal extent is higher than those of extensive contiguous forests. In terms of image interpretation and mapping, an interpreter has to identify and delineate many more forest units and boundaries which increases the probability of committing identification and boundary errors.

The objectives of this study were: 1) to map forests using different Landsat image products from two seasons; 2) identify and map all errors by comparing the Landsat-derived forest maps with a detailed forest cover type map; 3) assess the accuracy of interpretation; 4) analyze the factors contributing to error; and 5) evaluate time, cost and image availability considerations.

Barry County in southwestern Michigan was selected as the study area because a detailed forest cover type map and recent aerial photography were available. This county contains many scattered forested areas of various sizes and shapes within its land area of 144,780 hectares (357,751 acres). Over 26 percent of the county is covered by forests which consist of many of

the forest cover types found in Michigan. Of these forestlands, 99.2 percent are capable of producing commercial timber and two-thirds of them are in private ownership.

Agriculture is the major land use (55%) in the county and includes farming, livestock, dairy and poultry production. Principal crops are corn, wheat, oats, soybeans and dry beans.

Terrain varies from level in the eastern townships to gently rolling in the west. There are numerous wetlands although well-drained soils (loams and sandy loams) predominate throughout the county.

It was decided that the optimal Landsat image may be a cloudless winter scene with snow cover on the ground but not on the trees. Under this condition, the tonal contrast between forested areas and other land cover types is very high. For comparative purposes, an additional Landsat scene taken during the growing season would be used.

A Landsat scene from February 26, 1979 (E-30358-15475) and one from September 12, 1979 (E-30556-15460) were selected from available scenes produced on the EDIPS (EROS Digital Image Processing System) equipment. EDIPS imagery was preferred because the system has improved Landsat image quality by employing processing routines for radiometric and geometric corrections, haze removal and edge enhancement.

Two image products of each Landsat scene were selected for interpretation: a Band 5 positive and a false-color composite of the winter scene, and a false-color composite and a diazo-enhanced color composite of the fall scene. All of the images were 185mm x 185mm (7.3 in. x 7.3 in.) transparencies.

The diazo color composite was produced to enhance (contrast stretch) forested areas using a density-specified process. Film exposure for each band was determined through densitometric analysis of forest areas clearly depicted on all black-and-white band positives and use of characteristic density (sensitometric) curves for each diazo film. The false-color composite consisted of one yellow diazo copy of Band 4, three magenta copies of Band 5 and one cyan copy of Band 7.

The primary source of reference (ground truth) data was a recently completed forest cover type map of the county. The map was prepared from photointerpretation of 1:30,680 scale color infrared (CIR) photography taken in 1974. In cases where discrepancies between the Landsat forest maps and this map were found, available 1:24,000 scale CIR photography acquired in

1978 was used to resolve differences.

Separate forest maps and area estimates for the county were derived from visual interpretation of the four Landsat images. Forest areas as small as one hectare (2.5 acres) were delineated from these images onto 1:50,000 scale county base maps using a precision rear projection system.

The interpretation entailed the identification and delineation of the boundaries of all forest areas without considering forest type or condition, and was performed by one interpreter. Prior to interpretation, the interpreter trained himself to recognize the appearances of forestlands on each image through analysis of a test area. To minimize bias in interpretation decisions due to experience gained from a previous interpretation, the sequence of interpretation alternated between winter and fall scenes with a one-week break between scenes. An interpretation overlay showing the boundaries of forestlands was prepared from each Landsat image.

The existence of the forest cover type map of the county permitted a complete assessment of the accuracy of interpretation. All errors in each Landsat forest map were identified and delineated onto separate overlays (fig. 1) through comparing each map superimposed on top of the forest cover type map. Registration was done on an individual forest tract basis since the geometric projections of the Landsat imagery (Hotine Oblique Mercator) and the reference map (polyconic) were different.

Omission errors were classified into forest type, stand size and density classes and commission errors were divided into seven land cover/use categories (table I). The omission and commission errors were further separated into boundary or identification errors. Boundary errors are areal differences in the perimeter (size and shape) of individual forestlands between the Landsat maps and reference map. Errors due to misinterpreting an entire forest tract or identifying a non-forest cover area as forest were considered identification errors. Identification errors are the most serious because individual parcels of land of a certain class are absolutely lost by assigning them to another class.

Another category was identified but not included in the accuracy assessment because it did not represent Landsat classification error. This category consisted of individual forestlands that were correctly interpreted on the Landsat images but were not shown on the forest type map. These lands, verified on recent aerial photography, were considered "overlooked forests"

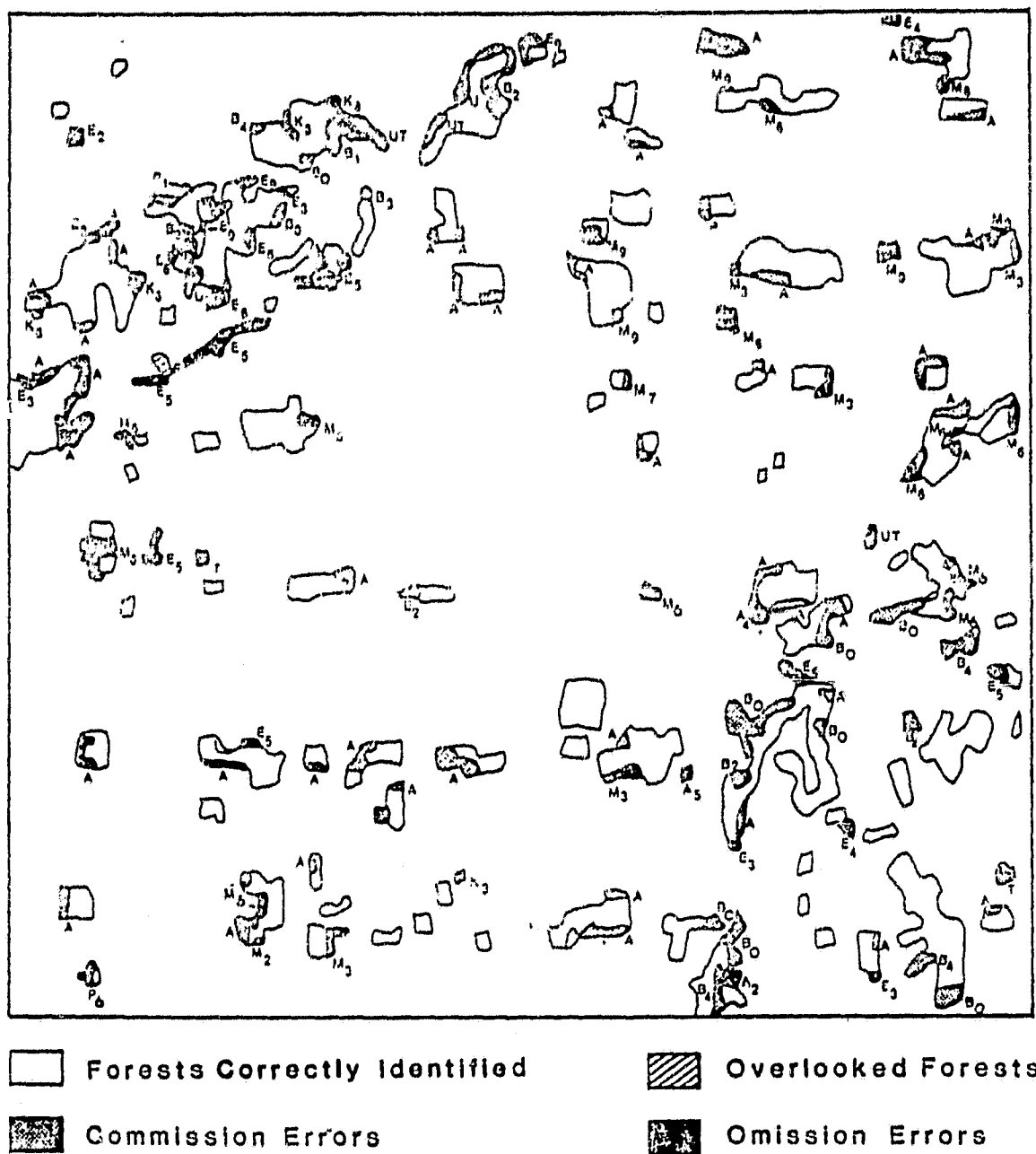


FIGURE 1. FOREST INTERPRETATION MAP FROM THE COLOR FALL IMAGE OF WOODLAND TOWNSHIP, BARRY COUNTY, SHOWING COMMISSION AND OMISSION ERRORS. SEE TABLE I. FOR EXPLANATION OF CODES.

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TABLE I. FOREST TYPE AND LAND COVER/USE CLASSIFICATION SYSTEM.

Error Class	Category	Symbol	Description
Omission	Pine	$P_0 \dots P_9$	Stands ranging from re-generation to full stocking sawtimber
	Oak-Hickory	$O_0 \dots O_9$	"
	Northern Hardwoods	$M_0 \dots M_9$	"
	Aspen	$A_0 \dots A_9$	"
	Lowland Hardwoods	$E_0 \dots E_9$	"
	Mixed Hardwoods	$K_0 \dots K_9$	"
	Conifer Swamps	$Q_0 \dots Q_9$	"
	Spruce-Fir	$S_0 \dots S_9$	"
	Locust	$B_0 \dots B_9$	"
Commission	Agriculture	A	Areas supporting agricultural crops
	Treed Bog	B_0	Adverse sites supporting trees with more than 10% crown cover
	Upland, Lowland Brush	$B_1 \dots B_4$	Areas with brush of variable maturity and stocking and trees of less than 10% crown cover
	Scattered Trees	T	Areas supporting trees with less than 10% crown cover
	Urban	U	Urban areas without trees or other brush vegetation
	Urban-Trees	UT	Urban areas with tree vegetation
	Water-Marsh	W	Areas permanently or periodically covered by standing water

on the reference maps. Forested areas which had been harvested since the compilation of the forest cover type map were also included in this category.

The frequency and areal extent of each type of error was determined for each Landsat map. Areas were estimated using a cell grid having a 0.25 hectare (0.625 acre) cell size. All values were rounded off to one decimal place.

Three types of agreement or accuracy were calculated: interpretation, classification and mapping. Interpretation agreement expresses the relative proportion of the total forest area mapped from Landsat to the total reference (actual) forest area of the county without considering errors of omission or commission. This type of accuracy is non-site specific and, therefore, is useful only if total area estimates are needed. Classification agreement expresses the relative proportion of the actual forest area that was correctly mapped as forest from Landsat taking into account only the omission errors. As such, it indicates how accurately individual forest tracts were identified without considering the misinterpretation of non-forested areas as forests (i.e., commission errors). Mapping agreement provides a measure of the locational or positional accuracy of the interpretation maps. It expresses the relative proportion of the actual forest area that was correctly mapped as forest, taking into account both errors of omission and commission.

The accuracies achieved with each type of Landsat image are given in table II. Overall, the accuracies ranged from 74.0 to 98.5 percent and were higher for the winter scene than the fall scene. Mapping accuracy (which has the greatest validity) was the highest for the winter false-color composite (88.3 percent), whereas the diazo enhancement of the fall scene improved the mapping accuracy over the fall false-color composite. Considering all types of accuracy, the winter false-color composite image provided the most accurate forest map of the county, although a diazo enhanced image of the winter scene may even further improve accuracy.

An investigation was made of the major factors affecting interpretation errors. A summary of the various interpretation errors by type of Landsat image is presented in table III. Over 83 percent of all commission and omission errors were boundary errors. The accuracy of identifying individual forest tracts from Landsat imagery (not considering their area) would, therefore, be substantially higher than those presented in table II.

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TABLE II. CLASSIFICATION, INTERPRETATION AND MAPPING AGREEMENT BY TYPE OF LANDSAT IMAGE.

TYPE OF LANDSAT IMAGE									
Agreement	Black-and-White Winter		Color Fall		Color Winter		Diaz Fall		Total Forested Acreage
	Acreage	%	Acreage	%	Acreage	%	Acreage	%	
Classification	56879.0	95.0	51513.2	86.0	55613.7	92.8	53571.9	89.3	59976
Interpretation	66161.5	89.5	61265.7	97.7	58720.5	98.1	60751.9	98.5	
Mapping	56879.0	82.2	51513.2	74.0	55613.7	88.3	53571.9	79.9	

TABLE III. ERRORS OF INTERPRETATION PERFORMANCE BY TYPE OF LANDSAT IMAGE¹
FOR BARRY COUNTY, MICHIGAN.

		TYPE OF LANDSAT IMAGE							
		Black-and-White Winter		Color Fall		Color Winter		Diaz Fall	
		Frequency	Acreage ²	Frequency	Acreage	Frequency	Acreage	Frequency	Acreage
		Abs. %	Abs. %	Abs. %	Abs. %	Abs. %	Abs. %	Abs. %	Abs. %
Commission	Boundary	1255 88.8	7988.7 86.1	1191 92.2	9113.9 91.1	482 87.6	2603.0 83.8	1127 96.1	6957.4 96.9
	Identification	158 11.2	1293.6 13.9	95 7.8	638.6 6.6	68 12.4	503.8 16.2	46 3.9	222.6 3.1
	Total	1413 100.0	9282.5 100.0	1291 100.0	9752.5 100.0	550 100.0	3106.8 100.0	1173 100.0	7180.0 100.0
Omission	Boundary	591 90.8	2670.8 89.1	1017 85.6	7294.4 87.2	878 91.1	1796.8 89.1	916 86.0	5465.1 86.7
	Identification	60 9.2	326.2 10.9	172 14.4	1068.4 12.0	86 9.9	465.5 10.9	152 14.0	839.0 13.3
	Total	651 100.0	2997.0 100.0	1189 100.0	8362.8 100.0	964 100.0	2262.3 100.0	1068 100.0	6304.1 100.0

¹ Total forest acreage: 59,876 acres.

² The acreage values represent the number of acres incorrectly interpreted. They are expressed in acres in all subsequent tables and graphs.

An analysis of the size of the error units showed that most areas were less than 4 hectares (10 acres) in size. Thus, if one is interested only in mapping forestlands larger than 4 hectares, the accuracy achievable may be improved.

Evaluation of the commission errors indicated that agricultural land was the major component of error, followed by treed bogs, brushland and urban trees. This was expected because of the high percent of boundary error and agriculture being the major land use in the county. However, accuracy may be improved if treed bogs and brushlands are considered forested areas.

The frequency and area of misinterpreted forest cover type categories (omission errors) were proportional to their occurrence in the county. Both stocking level (density) and stand size affected the interpretability of all forest cover types. Forest stands of lower stocking level and small stand size were more often misinterpreted, however, stocking level contributed more to omission error than stand size.

The amount of time spent on interpreting each Landsat image, including registration, training and interpretation, was recorded. The total time required to map the forests of the county ranged from about 13 hours for the winter color composite to 21 hours for the fall color composite.

Another factor considered was the availability of Landsat images for a given season. All available Landsat images of the county taken between 1972 and 1980 were classified according to frequency and percent cloud cover. A total of 186 Landsat images have been taken since 1972 and, of these, only 13 images (7 percent) have no cloud cover. Over 64 percent of all images and over 93 percent of the winter scenes have a cloud cover of more than 40 percent. The availability of cloud-free winter images is definitely much lower than clear fall images.

This study found that accurate acreage estimates of forestlands can be derived from Landsat imagery. The total forested area in Barry County was estimated to be within 3 percent of reference data, although site-specific accuracies of the Landsat images ranged from 74.0% to 88.3%. The false-color composite of the winter Landsat scene (with snow cover) provided the most accurate forest map and diazo enhancement improved the accuracy achievable from the fall Landsat scene.

In light of the accuracy levels achieved, and considering the relative efficiency and availability of the technology, the Forest Management Division, Michigan Department of Natural Resources, believes that Landsat-derived forest statistics can provide a valuable supplement to current forest resources data. It is also likely that Landsat can provide the first level forest area statistics in the periodic forest surveys and be used to up-date some of those statistics.

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A-2: Application of Remote Sensing for Assessment of Damage to Small
Grains Caused by the Cereal Leaf Beetle

Department of Entomology
Michigan State University
East Lansing, Michigan 48824
(517) 353-9081

Investigators from the Center for Remote Sensing, in collaboration with faculty of the MSU Department of Entomology, conducted a small pilot study aimed at incorporating information from remote sensing data into on-line integrated pest management programs. Objectives of the study were to evaluate remote sensing information as to its ability to provide cost-effective information on the location, intensity and extent of crop damage resulting from pests. Such information capabilities could lead to improved crop loss evaluation systems and/or more effective pest control procedures.

The cereal leaf beetle is a pest of small grains in many locations in eastern North America. The beetle was accidentally introduced into Michigan during the 1950's. It has since spread from its initial introductory location (Berrien County, Michigan) as far west as southern Wisconsin to the eastern seaboard. This pest can cause variable levels of damage to small grains. In some instances, losses have been estimated at 25 percent in oats. Damage occurs to leaves of the crop since the beetle adults and larvae feed on the upper leaf surface and remove green tissue.

Faculty investigators chose an on-going field experimental plot to test the remote detection capabilities of remote sensing. This field contained a replicated test of the effect of cereal leaf beetle on oats. Plots were randomly assigned a treatment of cereal leaf beetle infestation, moisture stress, cereal leaf beetle and moisture stress, and control plots. An aerial photographic mission was then flown over the test plots in June 1980.

A densitometric analysis was made of the color-infrared film which consisted of measuring transmittance through the individual dye layers of the film. An analysis of variance was conducted on the individual measurements and on ratios of the several dye layers. There were no significant differences between any level of beetle infestation and control plots. Water stress plots did show a significant difference from control plots and this warrants further investigation.

A-3: Remote Detection of X-Disease of Peach and Cherry Trees and of
Fire Blight of Pear and Apple Trees

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Investigators from the Center for Remote Sensing, in collaboration with faculty of the MSU Department of Botany and Plant Pathology, conducted a small pilot study aimed at incorporating information from remote sensing data into on-line integrated disease management programs. Objectives of the study were to evaluate remote sensing information as to its ability to provide cost-effective information on the location, intensity and extent of tree fruit damage resulting from diseases. Such information capabilities could lead to improved crop loss evaluation systems and/or more effective disease control procedures.

X-disease, caused by a mycoplasma, is a major problem in southwest Michigan and in certain other areas of the state of Michigan. Infected peach trees exhibit characteristic leaf symptoms, followed by defoliation, death of individual scaffold branches and then death of entire trees. Cherry trees often die in one or two seasons. The disease occurs over a wide area of southwest Michigan and is the major disease problem at this time. A method of rapidly determining disease incidence in individual peach and cherry orchards is needed to establish the effectiveness of control procedures and for conducting research on disease spread.

Fire blight, caused by the bacterium Erwinia amylovora, is the major disease problem faced by pear growers. Blight is also a problem on susceptible apple varieties. The disease causes loss of blossoms and fruit, but its most serious effect is reduced future production due to destruction of fruiting wood.

The objectives of this study were to determine the utility of aerial IR photography to detect disease infected trees in individual orchards located in southwest Michigan. Faculty investigators identified sample orchards which: 1) contain disease infected trees; 2) have ground collected data over several years; and 3) are owned by individuals who were willing to cooperate with the researchers. Actual flights were conducted during mid-summer when the disease symptoms first began to appear.

Investigators are currently analyzing the aerial photography to determine the ability to identify and quantify the two disease complexes.

A-4: Crop Area Estimation

MSU Agricultural Experiment Station
MSU Department of Crop and Soil Sciences
Michigan Agricultural Reporting Service

During August, 1980 the Center for Remote Sensing procured color-infrared, 70mm aerial photography from a light aircraft over the MSU Bean and Beet Experimental Farm and two private farms, all in Saginaw County. This demonstration flight was flown at the request of the MSU Agricultural Experiment Station and the Department of Crop and Soil Science, and the Michigan Agricultural Reporting Service.

Analysis of the acquired color-infrared aerial photography provided bean acreage estimates which were within a few percentage points of ground-determined acreages. The official Michigan dry bean area forecasts, as presently compiled, produce unacceptably high sampling errors. Based on the encouraging results from the Center's demonstration flight, the Michigan Bean Commission is sponsoring additional research to develop remote sensing techniques whereby present procedures of predicting crop acreages can be revised so that percentages of error can be reduced appreciably, thereby saving significant sums of money.

The Michigan Bean Commission has provided a \$10,000 grant to the Department of Resource Development, MSU, to support this applied research effort. The Department of Resource Development, in cooperation with the Center, will determine the usefulness and costs of aerial survey methods for obtaining aggregate bean area estimates. If successful, these techniques could be operationalized by the Michigan Bean Commission to provide reliable crop-specific area estimates at reduced costs.

A-5: Delimiting Areas of Virus Infection in Vineyards and Blueberry Fields
of Southwestern and Western Michigan

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(517) 355-4683

U.S. Department of Agriculture
National Grape Cooperative
Michigan Blueberry Growers Association

During May 1981, staff members from the Center acquired close-range, 35mm color and color infrared transparencies of grape vines and blueberry bushes which were propagated in the research greenhouses on campus. Examples of both healthy and diseased symptom-bearing individuals were photographed. These slides provided a "first look" at the utility of photography to detect peach rosette mosaic virus in grape vines and blueberry shoestring virus in highbush blueberries. Interpretation of this imagery showed that in certain diseased individuals, subtle chlorosis or leaf surface mottling was detectable on both film types but slightly more obvious on the color infrared photographs. No examples of diseased but symptomless plants were available for study. This experiment was also complicated by a probable nitrogen deficiency in some of the plants photographed which produced additional stress symptoms.

Peach rosette mosaic virus, to which Michigan's \$10 million per annum Concord grape crop is particularly susceptible, has cost the growers tens of millions of dollars over the last thirty years. In highbush blueberries, which contribute about \$25 million each year to the state's economy, the blueberry shoestring virus causes annual losses of about \$3 million. Both of these diseases have a multi-year dormant, symptomless period prior to the time visual symptoms appear. These infectious, symptomless plants make control of these diseases particularly difficult.

It is envisioned that remotely sensed imagery may be able to discriminate between healthy, diseased symptomless and symptom-bearing grape vines and blueberry bushes. If successful, this application of remote sensing will provide an effective, fast and relatively inexpensive procedure for growers to assess the true extent of infection within their fields and more completely control these devastating diseases.

During the upcoming growing season, large-scale color and color infrared 70mm aerial imagery will be acquired of test fields near Lawton (grapes), Holland (blueberries) and West Olive (blueberries), Michigan. Extensive ground truth information in these test plots will also be collected including ground-based and aerial tower photography (color, CIR and multiband) and botanical sampling. Extremely accurate laboratory procedures are available (ELISA testing) to detect the presence of either of these two diseases in cut samples of the plants providing precise control for our tests of remotely-sensed data.

Section B: C O N T R A C T U A L S E R V I C E S

The Center for Remote Sensing has been providing technical services since 1973 under contractual arrangements for public and private agencies which do not need remote sensing-derived information or analysis/evaluative processes frequently enough to justify establishing their own specialized technical staffs with the basic equipment, imagery resources and other logistical means. Those agencies that do have regular need for remote sensing personnel and processes and attempt to set up their own remote sensing laboratories (such as state departments of transportation) have either to try to recruit qualified technicians from a very limited market or arrange for training for their own personnel already on board.

The MSU Center has been able to help public and private agencies by serving, under contractual agreements, as consultants, to provide whatever remote sensing services may be needed.....from acquiring required imagery, doing the necessary interpretation, plotting, evaluating, preparing needed cartographic formats, developing computer software and analysis routines, etc. The Center is also able to provide training for industrial groups (like foresters), for Cooperative Extension Service specialists, for business personnel groups and for public agency personnel. Many of these kinds of service experiences generate further requests for assistance.

During this 1980-81 reporting year, four contractual units were completed:

- B-1: Important Farmlands Inventory
- B-2: Statewide Land Cover Mapping from Landsat
- B-3: Delineation of Possible Crop Stress Due to Excessive Soil Chlorides
- B-4: Michigan High Priority Sand Dune Areas Land Use Change Analysis

Case B-1, an inventory of important farmlands in a group of Michigan counties, is a continuing commission from the USDA Soil Conservation Service in force for several years whereby contracts are offered to the CRS at approximately yearly intervals to inventory additional blocks of five or more counties. Presumably, these contractual assignments will continue until all of the 83 Michigan counties will have been analyzed.

Case B-2 was commissioned by the Michigan Department of Transportation (DOT) to develop processes whereby available black-and-white imagery could be color-enhanced to produce sharper contrasts for land cover identification which could be more rapidly identified, delineated and digitized as inputs to the geographic information system of DOT. The products of the study were accepted as fully satisfactory for the agency's purposes.

Case B-3 was commissioned by the Dow Chemical Company which needed a reliable basis for determining the legitimacy of claims for crop loss and the amount of compensation, if needed, for crops damaged by alleged leaks in a brine pipeline. The CRS delivered the full information for which it was commissioned.

Case B-4 involved a contract from the Michigan Geological Survey Division to detect and classify land use changes over a 15-year period within the barrier dune formations of Michigan's high priority sand dune resources. Intrusions of residential and recreational land uses and activities have generated serious modifications and damage to the ecological structure of many areas of such fragile, unique resource areas. The resulting tabulations of information are being used by the state to establish revised priorities for the lands purchase program in the continuing efforts to preserve these dwindling precious resources.

These four commissioned studies do represent a wide variety of subjects. Yet they do offer certain similarities in that they were routine inventorying of the condition and characteristics of different conditions of terrain. Each of these studies were conducted at the request and initiation of the user agencies; and, as in the past, none of these were solicited by the Center.....all were requests from users who viewed remote sensing as the best, if not the only, means for obtaining the needed information. The accomplishment of these interesting four studies has advanced the technical capabilities and versatility of the Center staff; have added to the reputation and image of the Center as a highly reliable and productive operation. The Center principals are pleased to have been able to serve effectively important groups and agencies in Michigan and at the federal level.

B-1: Short Course in Remote Sensing for Forest Inventory

During the 1973-74 period, the MSU Remote Sensing Project conducted a study of the full territory of Mason County, Michigan at the request of the Mason County Soil Conservation Service and an industrial timber harvesting and wood products firm for their use in locating merchantable timber within economic haul of processing plants and in delineating the limits of ownership parcels. Both private and public forested tracts were analyzed.*

As a follow-up on that endeavor, a group of industrial and public agency foresters, operating in the Upper Peninsula of Michigan, requested the conduct of a short course on the application of remote sensing for inventorying forest resources with emphasis on the use of color-infrared photography.

In October 1980, the Center for Remote Sensing, in cooperation with Lifelong Education Programs and the Department of Forestry, conducted a three-day short course on the application of remote sensing for forest inventories at Bay De Noc Community College in Escanaba, Michigan.

This introductory short course was designed for practicing foresters who utilize and/or are familiar with aerial photography. The course focused on the use of medium-scale (1:24,000) color infrared aerial photography to map forest cover types. Specific topics included a review of basic principles of stereoscopy, photometrics and elements of airphoto interpretation, the characteristics and interpretation of color infrared photography and the application of airphoto interpretation of forest resources. One half-day session was devoted to field verification of an interpretation exercise.

Of the twenty participants who attended the short course, 11 were industrial foresters, one was an employee of the Gogebic County Forestry Commission and eight were from various offices of the U.S. Forest Service. Comments from these participants indicated that the course was a total success. Many felt that the techniques learned will allow them to gain more information from imagery, cut down on field work and make their inventory procedures more cost-effective.

*This Mason County study has been reported in three formats: a) as a special summary package report; b) as an item in the 1973 and 1974 semi-annual reports; and c) as a separately published complete report (1974).

B-2: Installation of Landsat Digital Processing System

Personnel from the Center for Remote Sensing and the Earth Resources Data Analysis Systems, Inc. (ERDAS) have completed the installation of the ERDAS micro-computer system. The Michigan State University Agricultural Experiment Station provided \$30,000 in funding to the Center for Remote Sensing for the purchase of the ERDAS system. The ERDAS system features both a grid-based geographic information software package and a Landsat digital analysis software package. Faculty and staff of Michigan State will utilize the ERDAS system for future research and application projects funded under the NASA grant.

The ERDAS system is a stand-alone computer system based around a Z-80 Central Processing Unit (CPU), supporting ASSEMBLER, BASIC, FORTRAN and PASCAL programming languages. Other hardware includes dual double density, double sided floppy disk drives, a joystick cursor control, CRT, matrix printer and RGB color monitor. The ERDAS system is interfaced with Michigan State's Control Data Corporation Cyber 750 mainframe computer to offer maximum data processing flexibility.

The Landsat software package is a modular interactive system permitting color display of a 240 by 256, three band, false color image of a user selected subscene. The Landsat software includes supervised training site selection, visual enhancement, haze correction, maximum likelihood classification and unsupervised classification. Output is in the form of a color display and computer line printer maps.

The IMGRID geographic information system is a menu driven, interactive grid based software system with a 512 by 480 color display. Designed to allow the user to easily integrate Landsat data into a geographic data base with other natural resource data such as soils, topography, etc., the IMGRID system allows the user to store and access natural resource information, provide rapid access and analysis capabilities and to create and evaluate alternative scenarios for resolution of land management issues. IMGRID output is in the form of color display and computer line printer maps.

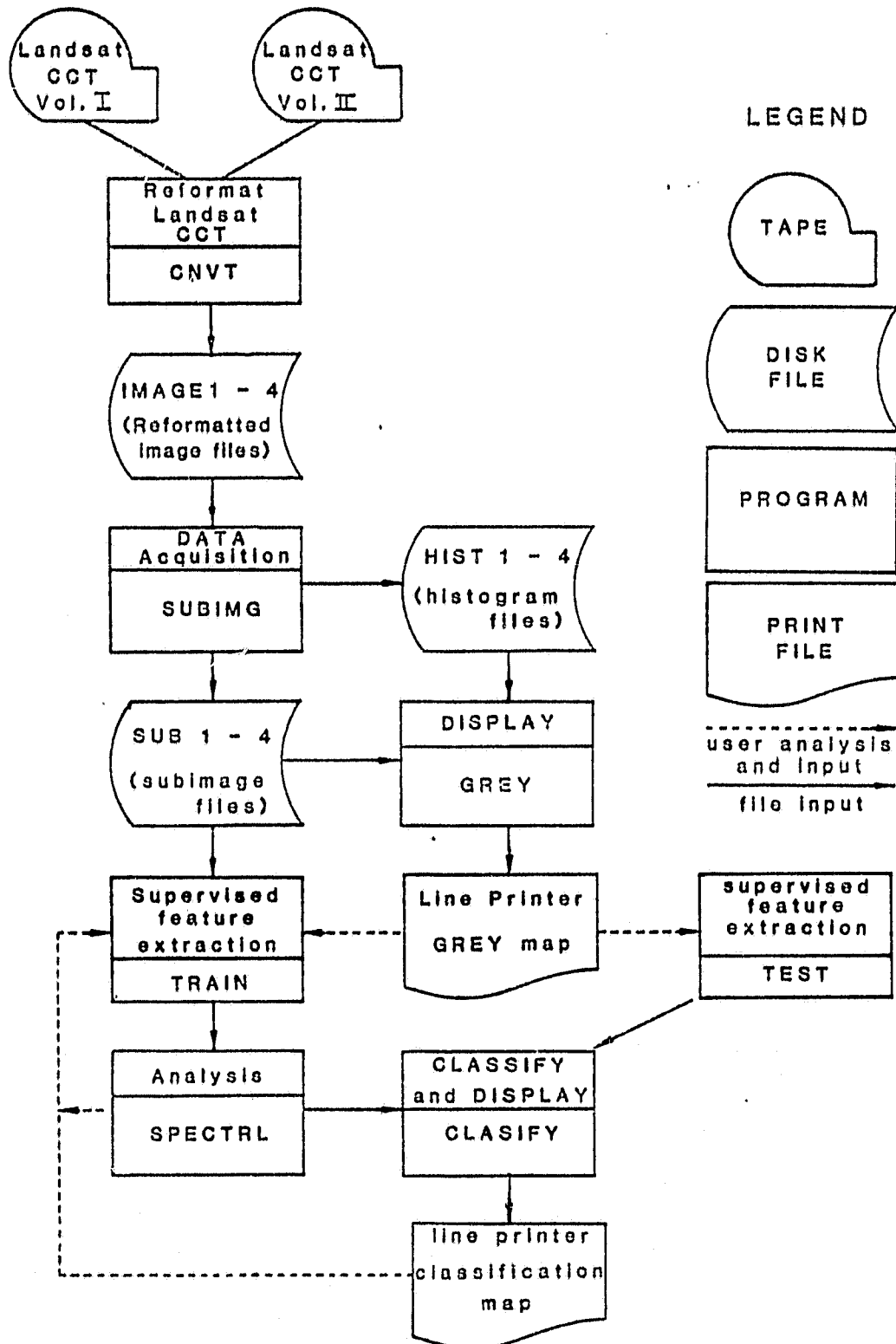
B-3: IMAGE 2 Software Developed

MSU's Center for Remote Sensing (CRS) has developed version 2.0 of the IMAGE Manipulation and Geographic Evaluation System. IMAGE 2 is a software package for the supervised classification of Landsat multispectral scanner data which is a part of the Center's technical aid in support of faculty and student research at Michigan State.

IMAGE 2 software provides students with an opportunity to learn the fundamental concepts of digital image processing and analysis through "hands-on" experience. The IMAGE 2 package consists of 7 BASIC language computer programs which are accessed through IMAGES, a Fortran language program that serves as an interface between the user and MSU's interactive system. The flow of information through the image processing system is shown on the following figure (Figure I). The functions of the individual programs consist of: CNUT--reformats any EDIPS BIL or BSQ CCT for use on MSU's CDC Cyber 750; IMAGES--a file handling routine which loads and executes user-selected IMAGE 2 software modules; SUBIMG--selects a subset from a reformatted disk file of the original Landsat scene; GREY--generates a computer line printer "gray scale" map of a user-selected Landsat band; TRAIN--selects rectangular areas to serve as training sets in a supervised classification; TEST--selects rectangular test sites to access the classification accuracy; SPECTRL--computes and outputs co-spectral plots for each training set; CLASIFY--a minimum distance classifier utilizing a maximum distance limit; and ACCNT--which selectively reviews or deletes subimages, training sets or test sets.

The IMAGE 2 package has recently been incorporated into the MSU Department of Geography's course in advanced remote sensing.

IMAGE2 Data Processing Flow



B-4: Informational Programs

Michigan State Remote Sensing Newsletter

The Center began producing a quarterly newsletter (the first edition was March 1981) which is distributed principally in-state. The purpose of the newsletter is to keep state, regional and local decision-makers informed about new remote sensing capabilities and applications and to reach new potential users.

SPECTRUM

SPECTRUM is intended to keep CRS investigators and others interested in remote sensing and its applications up-to-date on current news in the field. In SPECTRUM we attempt to brief readers on such things as upcoming meetings, workshops and seminars; staff travel; planned flights, etc. SPECTRUM is not released on a planned schedule--only as it is timely.

Seminar Series

The following seminars were sponsored by the Center during the reporting period:

"Remotely Sensed Multispectral Scanner Data--A Tool for
Soil Surveys"

Marion Baumgardner
Purdue University

"Dow Corning's Conversion to Wood Energy"

Phil Sworden
Dow Corning Corporation

"Geological Remote Sensing From Satellite Data"

Bob Vincent
Geospectra Corporation

"Direct Read-Out Meteorological Satellite Programs--Past,
Present and Future"

Ralph Taggart
Michigan State University

"Space Shuttle"/"Living in Space"

Daniel Tuzinowski
National Air and Space Museum

"Satellite Remote Sensing in the 1980's"

Roy Welch
University of Georgia

Section C: GENERAL MISSIONS ACCOMPLISHED

The highest and first priority missions of the Center are those of experimental research enterprises which test the utility of remote sensing technology for deriving crucial information needed for addressing effectively issues of high concern to society and its multiplicity of institutions. These kinds of missions carried out during the reporting year are described in Section "A" of this document. Of secondary priority are those missions performed for public and private institutions at their request and for which service they reimburse at least direct costs and many payments include coverage of estimated indirect costs (utilities, use of equipment and furnishings, administration/supervision). These "contractual services" executed for 1980-81 are reported under the preceding Section "B."

Both of the "A" and "B" categories of missions are more or less carried on simultaneously by different teams of research staff and faculty scientists. Staff principals perform the many roles within supervision and management and, in so doing, are overseeing all of the on-going activities. But, in addition to these dynamics, they are directing the inevitable array of daily tasks, such as responding to requests for information, materials (particularly imagery, maps, etc.) and assistance in application methods and interpretation.

Need for organizational training programs is an ever-present expression, but for which response cannot be provided without user-participants paying for costs incurred. With deteriorating fiscal constraints on every institution, the availability of funds for training short courses has become severely curtailed. It is most unfortunate that special funding for multi-level training cannot be obtained whereby agency and firm staffs can be progressively enabled to work with wider and deeper elements of remote sensing technology.

Interspersed with these research application and contractual units, training and informational services, the Center staff members are steadily laboring at strengthening their individual and team expertise which becomes the collective expertise of the Center for ultimate transference to faculty, students and agency personnel. These efforts are never-ending;

they must be continually carried forward as gaps of time, energy and momentum accommodate.

Two of these kinds of missions are reported in this section, namely C-2, Installation of Landsat Digital Processing System, and C-3, Image 2 Software Developed. Subsequent to this year being reported, activities in this category of expanding and strengthening the expertise of the Center in the skilled use of the newer emergent data sets and the computer-assisted means for eliciting maximum information from them and providing unequalled capabilities for comparative experimentation for the formulation of significant findings of high social and economic potential value have been advanced considerably. The "Introduction" section of this report addresses this point more fully in a different context.

The last unit reported herein, "C-4," is a collective synoptic report on a miscellany of information services which are considered by the Center principals as being a most important mission.

C-1: Important Farmlands Inventory

Soil Conservation Service
U.S. Department of Agriculture
1405 South Harrison Road
East Lansing, Michigan 48823

Contracts: 1. April 1979-December 1979
\$20,000
2. February 1980-September 1980
\$21,500
3. June 1980-June 1981
\$27,430
4. March 1981-December 1981
\$17,060

The Center for Remote Sensing is continuing work under contract with the Soil Conservation Service in preparation of Important Farmlands maps for counties in Michigan. A total of twenty-five counties are covered by the four contracts. The mapping involves the delineation of prime soil (U.S. Department of Agriculture, Secretary's memorandum number 1827, revised, October 30, 1978) areas from soil survey information and the identification of unique farmland, water and urban built-up areas from aerial photography. Unique farmlands are lands other than those designated prime that are used for the production of specific high-value food and fiber crops (e.g., tree and bush fruits, vineyards and vegetables).

The information is compiled onto a 1:50,000 base map of each county and area statistics per category are determined. The Important Farmland maps are being produced under the Land Inventory and Monitoring (LIM) program of the U.S. Department of Agriculture.

C-2: Statewide Land Cover Mapping From Landsat

Michigan Department of Transportation
State Highway Building
Lansing, Michigan 48933
(517) 373-2090

Contract: \$1,760

The MSU Center for Remote Sensing produced diazo-enhanced Landsat images for the entire state of Michigan under a \$1,760 purchase agreement with the Michigan Department of Transportation (MIDOT). Black-and-white 185mm positive transparencies for 23 Landsat nominal centers are being enhanced for land cover identification by means of diazo density-specified false-color composites. MIDOT personnel used this enhanced imagery to map forest, urban, agricultural and other lands onto stable-base copies of 1:250,000 scale USGS quadrangles using a precision rear projection system at the Center. These delineated data will be digitized and entered into the MIDOT computer system to provide an initial statewide data base. This data base will be used to test computer system capabilities and data output products for broad planning purposes as a precursor to developing a statewide geographic information system.

C-3: Delineation of Possible Crop Stress Due to Excess Soil Chlorides

Dow Chemical USA
Michigan Division
Midland, Michigan 48640
(517) 636-5527

Contract: \$1,000

In September 1980, Center staff acquired large-scale 70mm color and color infrared photographs of four small agricultural sites which were suspected of having been damaged by leaks in a brine pipeline. The photography was interpreted to delineate several zones of varying crop vigor and soil moisture conditions. These categories were chosen as being potentially useful for assessing the impacts of excessive chlorides in the soil and included 1) apparently healthy soybeans predominant, 2) senesced soybeans predominant, 3) mixed cover of soybeans and open dry soil, 4) mixed cover of soybeans and open wet soil, 5) open dry soil, and 6) open wet soil. A map of these delineated categories was prepared at a scale of 1:1,200 (1":100') and the acreage of each class was calculated using a high-density dot grid. The map and photographs were delivered to Dow Chemical for their use in determining the legitimacy of claims for crop loss and the amount of compensation, if any.

C-4: Michigan's High Priority Sand Dune Areas Land Use Change Analysis Study

Geological Survey Division
Michigan Department of Natural Resources
Stevens T. Mason Building
Lansing, Michigan 48933
(517) 373-3328
Contract: \$9,200

The Center for Remote Sensing, under a \$9,200 contract from the Michigan Department of Natural Resources, completed a study to detect and classify land use changes over the past 15-year period within the barrier dune formations of Michigan's high priority sand dune areas. The study areas are dune environments within two miles of the Great Lakes' shoreline that have been designated by the Michigan Department of Natural Resources, as mandated by the "Sand Dune Protection and Management Act" (Act No. 222, P.A. 1976). About 22 square miles (14,161 acres or 5,735 hectares) of the Lake Michigan sand dune shoreline were analyzed.

The specific objectives of the study were:

- a. To identify and delineate on acetate overlays all present (1978) developed and undeveloped land (2.5 acres or more in size) within the barrier dune formations (utilizing 1978, 1:24,000, color infrared aerial photographs).
- b. To identify and delineate on acetate overlays the pattern of developed/undeveloped land at an earlier time (utilizing 1963 to 1967, 1:20,000 or 1:15,840, black-and-white panchromatic aerial photography).
- c. To compare the past and present developed/undeveloped land to determine the location and extent of land development since the 1963 to 1967 time window.

The study showed that less than one-fifth (18.0 percent) of this 22 square mile aggregate sensitive environmental zone has been developed to date. The results of the change-detection analysis show that 754 acres of new land development has occurred on these dunes since 1963. Although this represents only 5.3 percent of the total dune study area, it reveals that 29.6 percent of all presently developed land became converted in just the last 15 years. The greatest development pressure on these barrier dunes results from continuing expansion of residential land uses. All other land use conversions combined constituted less than 15 percent of the dune land conversions in the study area since 1963.

Determining the magnitude and location of these land use changes within the sand dune area will allow the state to prioritize its acquisition program of preserving unique dune environments.

Section D: I N F O R M A T I O N A L S U M M A R Y -- Update of Quantitative Information on Center Operations

The 1979 Annual Progress Report included for the first time a section which has since become a standard component of annual reporting. Reference is made here to the "Informational Summary," a systematic tabulation of specified data about cumulative features and accomplishments of the Center for Remote Sensing, including those elements carried on with NASA grant funds and those with other funding resources.

The categories of reported information were specified by the University Applications Program of NASA. This up-date includes the period of time up through May 31, 1981 and consists of the following categories:

- Category One: Projects Conducted with NASA Grant Funds
- Category Two-(a): NASA-Funded Projects by Cooperating Agency
- Category Two-(b): NASA-Funded Projects by Data Source
- Category Three: All Other Funding Received
- Category Four: Commercial Spin-Offs from NASA-Funded Projects
- Category Five-(a): Educational Activities
- Category Five-(b): Number of "Remote Sensing" Courses Offered
on Campus and Enrollments
- Category Six: Agency Contacts
- Category Seven: Consultations with the Center Personnel--An
Approximation

Section D: I N F O R M A T I O N A L S U M M A R Y -- Update of Quantitative Information on Center Operations

Category One: PROJECTS CONDUCTED WITH NASA GRANT FUNDS

1. M-14 Highway Environmental Impact Assessment (Michigan Department of State Highways and Transportation; 1972): Remote sensing data from high and medium altitude photography provided information on land use, vegetation, soils, and hydrologic characteristics of a proposed highway corridor in Washtenaw County which provided the bases for assessing the potential environmental impact of this highway construction. The MDSHT subsequently adopted procedures for route location determinations based on remote sensing techniques and the findings of the M-14 research.
2. Pte. Mouillee Waterfowl Habitat Assessment (Michigan Department of Natural Resources; 1972-73): Wetland vegetative communities and shoreline erosion in a marsh area on Lake Erie were mapped using remote sensing data from high, medium, and low altitude photography. Recommendations were made, in collaboration with the DNR, for improving marsh management, alleviating erosion, and reclaiming land lost through erosion. Many of these measures were progressively implemented, such as purchase of adjoining land for expanded habitat.
3. Upper Kalamazoo River Basin Inventory (Soil Conservation Service; 1973): The first extensive Michigan land cover/use inventory from NASA high altitude CIR photography was prepared for a 2,590 sq. km. (1,000 sq. mi.) area of the river basin. SCS used the information in analyzing wildlife habitats and wetlands from which specific management priorities and county recommendations were identified.
4. Michigan Department of State Highways and Transportation Environmental Inventory (MDSHT; 1973): NASA RB-57 imagery and technical assistance in photo interpretation were provided to MDSHT as the Department implemented remote sensing procedures (developed under the M-14 highway project) for assessing the environmental impact of four proposed highway corridors. MDSHT now operationally uses remote sensing procedures and has contracted aerial survey firms to acquire new imagery.
5. Tri-County Regional Planning Commission Land Use Update (TCRPC; 1973): NASA RB-57 imagery and technical assistance in photo interpretation were provided to Commission personnel for updating a 1965 land use inventory. A spin-off occurred in 1976 when the MSU Project prepared a land use inventory for the three-county area under a contract from TCRPC.

6. Michigan Land Cover/Use Classification System (Michigan Department of Natural Resources; 1974): RSP personnel helped develop a four-level statewide land cover/use classification system based on remote sensing as the primary data source. The system was operationally tested by the RSP using a variety of remote sensing data which resulted in several categorical changes. The classification system has been in use by the DNR and other agencies as a standard operational routine ever since.
7. Kent County Land Resource Information System (West Michigan Regional Planning Commission; 1974): Land use data was derived from aerial photos and encoded for use in a computer information system being developed by the WMRPC. The system has been expanded to cover the entire nine-county region and the WMRPC contracted private firms to provide aerial photo coverage and land use data for its region.
8. Mason County Forest Inventory (West Michigan Regional Planning Commission, Mason County Soil Conservation District, and Packaging Corporation of America; 1974): Forests were classified into species groups, stocking levels and maturity classes from high-altitude CIR imagery. The forest information is being used by wood procurement firms to locate marketable timber and by SCS in establishing forest management cooperatives. The study helped the Michigan DNR secure funding support from 21 private forest industries for statewide CIR photo coverage.
9. Retention of Agricultural Land in Wayne County (Wayne County Planning Commission and Cooperative Extension Service; 1974): NASA RB-57 imagery and photo interpretation training were provided to WCPC staff who then prepared agricultural and open land use maps. The maps were used to identify lands which were zoned for retention in agricultural or open space use in five townships that fringe the Detroit Metropolitan area. Three townships amended master development plans to implement these decisions. Litigations have delayed amending zoning ordinances to conform to plans.
10. Grand Traverse County Special Environments Inventory (Michigan Department of State Highways and Transportation and Traverse Bay Regional Planning Commission; 1974): Personnel of the RSP and the MDSHT jointly developed a 24-category land use and 34-category special environments inventory from CIR imagery and a computer information system for the County. The system was used in selecting a site for an industrial park and in locating optimal low environmental impact highway corridors.
11. Implementation of Michigan Soil Erosion and Sedimentation Control Act (Antrim County Planning Department; 1974): CIR imagery provided an expeditious, legally acceptable means for evaluating the site construction plans required in earth-change operations and for detecting potential violations of the Act.

12. Charlevoix County Land Value Appraisal (Charlevoix County Equalization Department; 1975): NASA RB-57 imagery and photo interpretation training were provided to Department personnel. Land cover maps of the major islands in the county located in Lake Michigan were prepared and used in reassessing all property valuations by the Department.
13. Antrim County Abandoned Vehicle Inventory (Antrim County Planning Department; 1975): Abandoned vehicles in the County were identified from CIR imagery and the inventory results were used by the Department to direct junk vehicle removal activities.
14. Optimizing Agri-Business Processing Plant Location (Wickes Agriculture; 1975): All tillable land within Gratiot County was identified from NASA RB-57 and Skylab imagery. Using this information and soils data, a computer routine generated potential crop productivity estimates for alternative crop processing plant sites and service areas and confirmed a location for a new plant.
15. Assessment of Recreation Potential for Backcountry Rivers (U.S. Forest Service and MSU Department of Geography; 1975): Interpretation of aerial photography provided a range of information necessary for an assessment of the recreational potential of the Pine River in the Manistee National Forest. Photo-derived data for 38 variables were integrated with float survey data and weighted in relation to 16 potential recreational uses by a computer routine.
16. Aerial Detection of Stressed City Trees (City of Lansing Parks & Recreation Department; 1975): The interpretation of large-scale 35 mm CIR transparencies provided a 35 percent increase in the detection of total number of stressed trees as compared to the number detected by conventional eye-level surveys. Photo interpretation, in turn, missed detecting some stress observed on the ground, indicating that remote sensing can supplement but not replace conventional techniques.
17. Crop Damage Assessment (MSU Department of Crop and Soil Sciences; 1975): Three levels of damage to a navy bean field due to excessive rainfall were identified and quantified from large-scale 35 mm photos. Photo-based yield estimates were compared with estimates made by a crop insurance representative and were found to be an accurate method for determining an equitable settlement.
18. Survey and Analysis of the Detroit Riverfront (Wayne County Planning Commission, State of Michigan Department of Commerce, and Department of Natural Resources; 1975-76): As a component of a multi-agency task force study, the MSU/RSP completed inventories of marinas, nature and extent of industrial uses of river-abutting land including material stockpiles, plus all other land and water uses. Data gained from NASA RB-57 imagery and RSP-acquired low-altitude 35 mm color photos demonstrated current conditions and provided useful information for

determining the development potential of 37 miles of riverfront. Specific recommendations were made by the task force. Fifteen sets (20-40 slides) of the 35 mm photos have been purchased by public and private agencies.

19. Energy Park Site Selection (Consumers Power, Detroit Edison, ERI and MSU Department of Agricultural Engineering; 1975): The physical characteristics of seven potential energy park sites were derived from NASA RB-57 imagery supplemented by 35 mm oblique photos. The information was evaluated to determine which site was best suited for agricultural and aquacultural applications of waste heat.
20. Inventory of Potential Mosquito Breeding Sites for Vector Control (City of Lansing Vector Control Section; 1975-76): All standing water and wetlands in the Lansing area were mapped from 70 mm aerial photos acquired by the RSP. The maps indicate 33 percent more potential mosquito breeding sites than previously known and are operationally used as the primary reference document by field treatment teams.
21. Inventory of Surface Water Accessible to Fire Trucks (Antrim County Planning and Fire Departments; 1975-77): Surface water locations, potential access sites for recharging fire truck water supplies, and physical limitations to recharging were identified from 1:36,000 CIR photos. Township maps and computer listings of the information are used by firemen to locate the closest suitable water source and access point from the site of a fire.
22. Agricultural-Use Valuation (Eaton County Equalization Department, West Michigan Regional Planning Commission and Kent County Equalization Department; 1975-76): A computer-assisted farmland appraisal system which utilizes remotely sensed land use data was developed for two townships. The RSP has subsequently prepared farmland appraisal computer maps for all of Eaton County on a cost-reimbursable basis.
23. Search for Buried Murder Victims in Berrien County (Office of the Prosecuting Attorney, County of Berrien; 1976): A variety of aerial imagery and real-time thermal data were used to identify possible murder victim burial sites on a suspect farm. The information provided documentation for securing a search warrant and facilitated a systematic and efficient search of the property by State Police teams; however, no bodies were recovered.
24. Merging Land Cover/Use Data from Landsat, Aerial Photography and Map Sources (Bendix Aerospace Systems Division; 1976): The RSP and Bendix jointly developed a procedure to merge photo-derived land use data with computer-categorized Landsat data in order to maximize effective use of both data sources in the provision of an integrated information system for regional analysis. The procedure was subsequently used in a three-county land use inventory performed under contractual funds.

25. Resource Analysis Program--RAP (Tri-County Regional Planning Commission; 1976-77): RAP, a grid-based computer mapping system, was developed for integration, comparative analysis, and display of remotely sensed data and other natural resource information. The RAP system has been used in several townships, four counties, and one foreign country for mapping projects conducted with contractual funds.

26. Analysis of Biomass of Old Field Ecosystems Used for Waste Water Recycling (MSU Institute of Water Research; 1976): Large-scale 35 mm CIR photos were used to estimate plant biomass of experimental plots in an old-field ecosystem that was being treated with different levels of sewage treatment waste-water. The method accurately estimated plant biomass as early as one month before harvest, is more accurate and cost-efficient, and demonstrates a real potential in the improvement of management of waste-water irrigation projects.

27. Preservation of the Grand Mere Dune Environment (Grand Mere Association; 1976-77): The loss of dune vegetative cover between 1970 and 1976 due to Off-Road-Vehicle (ORV) activities was determined by a temporal analysis of aerial photography. This study led to an ORV enforcement program, initiated under a special appropriation of funds for the township police department, which has subsequently reversed vegetative recession.

28. Muskegon Sand Mining Inventory (Michigan Department of Natural Resources; 1977): A procedure to inventory and monitor sand mining operations using existing aerial imagery and specifically acquired 70 mm photos was developed. The procedure is being used in implementing the Michigan Sand Dune Protection and Management Act (1976) under contractual arrangements between the DNR and the RSP.

29. Re-Evaluation of the I-69 Highway Corridor (Citizens Concerned About I-69; 1978): The selection of a corridor for the extension of Interstate Highway 69 in central Michigan has been challenged by the Citizen's group. Two major issues are involved in the discussion of alternative corridors: the loss of prime farmlands and the effect on wetlands. A land cover map of the area in question from NASA high-altitude CIR imagery, was provided to the Citizen's group to assist them in formulating their arguments. The issue is currently being decided in the courts.

30. Mosquito Control in Saginaw and Bay Counties (Saginaw-Bay Mosquito Control Commission; 1978): Information on potential mosquito habitats and residential areas derived from aerial photography has been used by the SBMCC to prioritize treatment areas and formulate operational strategies for the control of early season Aedes mosquitoes.

31. Identification of Wild Areas in Southern Lower Michigan (Michigan Department of Natural Resources; 1978): The RSP has developed a procedure to identify "wild areas" using Landsat and aerial imagery in a multi-stage process. Environmental characteristics of candidate sites were

interpreted from photos and used in a grading system to determine a final point value for each area. The Michigan DNR is using this information to identify sites which they will recommend for dedication as natural preserves.

32. Identification of Wood Energy Resources in Central Michigan (Morbark Industries, Inc., Dow-Corning Corporation, Consumers Power Company and Wolverine Electric Cooperative; 1978-79): Landsat imagery, supplemented by NASA RB-57 and other aerial photography, was used to determine the location, extent and biomass of non-commercial timber resources in a candidate multi-county supply area. The information was used in determining that a wood-chip burning electric power generating plant is feasible.
33. The Impacts of Pipeline Construction on Stream and Wetland Environments (Michigan Public Service Commission; 1978-79): Analysis of temporal aerial photos was conducted to assess environmental (particularly drainage alteration) impacts of existing gas and oil pipeline crossings of streams and wetlands. While most "damages" were found to be non-pipeline related, improper construction techniques were found to cause damage to these fragile ecosystems.
34. Identification of Hazardous Waste Disposal Sites (Michigan Department of Natural Resources; 1979-80): Time-sequential maps of areas around specified chemical plants were compiled from historical and current aerial photography (1938-1979). These maps, along with new large-scale color, aerial photography, will be tested by the DNR to determine their effectiveness at locating critical disposal sites.
35. Integrated Pest Management Systems (Departments of Botany and Plant Pathology and Entomology, Michigan State University; On-going): CRS investigators, in collaboration with MSU faculty, are investigating damage distribution assessment and biomass loss to small grains caused by the cereal leaf beetle. If detection and analysis appear successful, a county transect inventory will be attempted. These results should provide immediate input to the state's on-going disease control program. A similar study is being conducted over orchards which are suffering from X-disease or fire blight.
36. Analysis of Landsat Data in Updating Forest Inventories (Cooperative Extension Service and Packaging Corporation of America; 1980): Center investigators have designed and tested an updating procedure using Landsat data (CCT's, black-and-white imagery and diazo composites) to detect and identify changes in the forest since the original inventory. This procedure may provide the only cost-effective method available to update existing forest mapping inventories.
37. Forest Area Determination from Landsat Data (Michigan Department of Natural Resources; 1979-1980): An assessment of Landsat data products (i.e., individual black-and-white MSS images, conventional false-color composite images, RBV data and computer classified MSS digital data) was conducted to evaluate their suitability for identifying and estimating the areas of woodlots in the southern Lower Peninsula of Michigan. The DNR will use the results as a basis for planning an operational Landsat monitoring system.

38. Landsat-Based Pipeline Routing Decisions (Michigan Public Service Commission; 1980): Analysis of Landsat MSS imagery was used to produce current land cover maps of the eastern one-half of the northern Niagaran Trend region of Michigan. The MPSC is using this information as a basis for recommendations of the right-of-way routes which would minimize adverse environmental impacts of pipeline construction.
39. Crop Area Estimation (MSU Agricultural Experiment Station, MSU Department of Crop and Soil Science and Michigan Agricultural Reporting Service; 1980): Color-infrared, 70mm aerial photography from a light aircraft was acquired over the MSU Bean and Beet Experimental Farm. Analysis of the aerial photography provided bean acreage estimates which were within a few percent of ground-determined acreages. Additional research is being sponsored to develop operational procedures for predicting crop acreages.
40. Estimation of Soil Map Unit Composition (Soil Conservation Service and Michigan Department of Agriculture; on-going): Electronic scanning equidensitometry of existing aerial photography is being investigated as a means of rapidly providing estimates of mapping unit composition. These methods are being evaluated for inclusion in current soil survey procedures.
41. Delimiting Areas of Virus Infection in Vineyards and Blueberry Fields (National Grape Cooperative and Michigan Blueberry Growers Association; on-going): CRS investigators, in collaboration with MSU faculty, are investigating the utility of remote sensing imagery to discriminate between healthy and diseased symptomless and/or symptom-bearing grape vines and blueberry bushes. If successful, these procedures could provide an effective, quick and relatively inexpensive method for growers to periodically assess the extent of infection within their fields.

MSU/Center for Remote Sensing

Category Two-(a): NASA FUNDED PROJECTS BY COOPERATING AGENCY

TYPE	COOPERATING AGENCY	PROJECT	PROJECT NUMBER
Federal	Soil Conservation Service	Upper Kalamazoo River Basin Inventory	3
		Mason County Forest Inventory	8*
	U.S. Forest Service	Estimation of Soil Map Unit Composition	40*
		Assessment of Recreational Potential for Backcountry Rivers	15
State	Michigan Department of State Highways and Transportation	M-14 Highway Environmental Impact Assessment	1
		MDSHT Environmental Inventory	4
		Grand Traverse County Special Environments Inventory	10*
	Michigan Department of Natural Resources	Pte. Mouille Waterfowl Habitat Assessment	2
		Michigan Land Cover/Use Classification System	6
		Muskegon Sand Mining Inventory	28
		Identification of Wild Areas in Southern Lower Michigan	31
		Identification of Hazardous Waste Disposal Sites	34

*Project listed under more than one agency

Category Two-(a) (con't)

TYPE	COOPERATING AGENCY	PROJECT	PROJECT NUMBER
State	Michigan Department of Natural Resources (con't)	Forest Area Determination from Landsat Data	37
	Michigan Public Services Commission	The Impacts of Pipeline Construction on Stream and Wetland Environments	33
		Landsat-Based Pipeline Routing Decisions	38
	Michigan Department of Agriculture	Crop Area Estimation	39*
		Estimation of Soil Map Unit Composition	40*
Regional	Tri-County Regional Planning Commission	TCRPC Land Use Update	5
	West Michigan Regional Planning Commission	Resource Analysis Program	25
		Kent County Land Resource Information System	7
		Mason County Forest Inventory	8*
		Agricultural-Use Valuation	22*
	Traverse Bay Regional Planning Commission	Grand Traverse County Special Environments Inventory	10*

*Project listed under more than one agency

Category Two-(a) (con't)

TYPE	COOPERATING AGENCY	PROJECT	PROJECT NUMBER
County	Wayne County Planning Commission	Retention of Agricultural Land in Wayne County	9
		Survey and Analysis of the Detroit Riverfront	18
	Antrim County Planning Department	Implementation of Michigan Soil Erosion and Sedimental Control Act	11
		Antrim County Abandoned Vehicle Inventory	13
	Charlevoix County Equilization Department	Charlevoix County Land Value Appraisal	12
		Agricultural Use Valuation	22*
	Eaton and Kent County Equilization Departments	Search for Buried Murder Victims in Berrien County	23
		Mosquito Control of Saginaw and Bay Counties	30
	Saginaw-Bay Mosquito Control Commission		
Town-Local	City of Lansing	Aerial Detection of Stressed Trees	16
		Inventory of Potential Mosquito Breeding Sites for Vector Control	20
	Departments of Michigan State University	Crop Damage Assessment	17
		Analysis of Biomass of Old Field Ecosystems Used for Waste Water Recycling	26

*Project listed under more than one agency

Category Two-(a) (con't)

TYPE	COOPERATING AGENCY	PROJECT	PROJECT NUMBER
Town-Local	Departments of Michigan State University (con't)	Integrated Pest Management System	35
		Analysis of Landsat Data in Updating Forest Inventories	36*
		Crop Area Estimation	39*
	Grand Mere Association	Preservation of the Grand Mere Dune Environment	27
	Citizens Concerned About I-69	Re-Evaluation of the I-69 Highway Corridor	29
Private	Packaging Corporation of America	Mason County Forest Inventory	8*
		Analysis of Landsat Data in Updating Forest Inventories	36*
	Wickes Agriculture	Optimizing Agri-Business Processing Plant Location	14
	Consumers Power and Detroit Edison	Energy Park Site Selection	19
	Bendix Aerospace Systems Division	Merging Land Cover/Use from Landsat, Aerial Photography and Map Sources	24
	Morbark Industries, Inc.; Dow-Corning Corporation; Consumers Power and Wolverine Electric Co-op	Identification of Wood Energy Resources in Central Michigan	32

*Project listed under more than one agency

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Category Two-(a) (con't)

TYPE	COOPERATING AGENCY	PROJECT	PROJECT NUMBER
Private	National Grape Cooperative and Michigan Blueberry Growers Associa- tion	Delimiting Areas of Virus Infection in Vineyards and Blueberry Fields	41

Category Two-(a) (con't)

AGENCY	NUMBER OF PROJECTS	PERCENT
Federal	4	8.5
State	13	27.7
Regional	6	12.8
County	8	17.0
Town-Local	9	19.1
Private	<u>7</u>	<u>14.9</u>
TOTAL	47	100.0

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Category Two-(b): NASA FUNDED PROJECTS BY DATA SOURCE

SOURCE	PROJECT	PROJECT NUMBER
Landsat	Michigan Land Cover/Use Classification System	6*
	Merging Land Cover/Use Data from Landsat, Aerial Photography and Map Sources	24*
	Identification of Wild Areas in Southern Lower Michigan	31*
	Identification of Wood Energy Resources in Central Michigan	32*
	Analysis of Landsat Data in Updating Forest Inventories	36
	Forest Area Determination from Landsat Data	37
	Landsat-Based Pipeline Routing Decisions	38
Skylab	Michigan Land Cover/Use Classification System	6*
	Optimizing Agri-Business Processing Plant Locations	14*

*Project utilized more than one source

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Category Two- (b) (con't)

SOURCE	PROJECT	PROJECT NUMBER
High Altitude Aircraft	M-14 Highway Environmental Impact Assessment	1*
	Pte. Mouillee Waterfowl Habitat Assessment	2*
	Upper Kalamazoo River Basin Inventory	3
	MDSHT Environmental Inventory	4
	Tri-County Regional Planning Commission Land Use Update	5
	Michigan Land Cover/Use Classification System	6*
	Retention of Agricultural Land in Wayne County	9
	Charlevoix County Land Value Appraisal	12*
	Optimizing Agri-Business Processing Plant Location	14*
	Survey and Analysis of the Detroit Riverfront	18*
	Energy Park Site Selection	19*
	Agricultural-Use Valuation	22
	Merging Land Cover/Use Data from Landsat, Aerial Photography and Map Sources	24*
	Resource Analysis Program	25
	Muskegon Sand Mining Inventory	28*
	Re-Evaluation of I-69 Highway Corridor	29

*Project utilized more than one source

Category Two-(b) (con't)

SOURCE	PROJECT	PROJECT NUMBER
High Altitude Aircraft	Mosquito Control in Saginaw and Bay Counties	30
	Identification of Wild Areas in Southern Lower Michigan	31*
	Identification of Wood Energy Resources in Central Michigan	32*
	The Impacts of Pipeline Construction on Stream and Wetland Environments	33*
	Identification of Hazardous Waste Disposal Sites	34*
Medium Altitude Aircraft	N-14 Highway Environmental Impact Assessment	1*
	Pte. Mouillee Waterfowl Habitat Assessment	2*
	Michigan Land Cover/Use Classification System	6*
	Mason County Forest Inventory	8
	Grand Traverse County Special Environments Inventory	10
	Implementation of Michigan Soil Erosion and Sedimentation Control Act	11
	Antrim County Abandoned Vehicle Inventory	13
	Assessment of Recreational Potential for Backcountry Rivers	15
	Survey and Analysis of the Detroit Riverfront	18
	Inventory of Surface Water Accessible to Fire Trucks	21

*Project utilized more than one source

Category Two-(b) (con't)

SOURCE	PROJECT	PROJECT NUMBER
Medium Altitude Aircraft	Search for Buried Murder Victims in Berrien County	23*
	Preservation of the Grand Mere Dune Environments	27*
	The Impacts of Pipeline Construction on Stream and Wetland Environments	33*
	Identification of Hazardous Waste Disposal Sites	34*
	Estimation of Soil Map Unit Composition	40
56		
Low Altitude Aircraft	Pte. Mouillee Waterfowl Habitat Assessment	2*
	Kent County Land Resource Information System	7
	Aerial Detection of Stressed City Trees	16
	Crop Damage Assessment	17
	Survey and Analysis of the Detroit Riverfront	18*
	Energy Park Site Selection	19*
	Inventory of Potential Mosquito Breeding Sites for Vector Control	20
	Search for Buried Murder Victims in Berrien County	23*
	Analysis of Biomass of Old Field Ecosystems Used for Waste Water Recycling	26
	Preservation of the Grand Mere Drne Environment	27*
	Muskegon Sand Mining Inventory	28*

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*Project utilized more than one source

Category Two-(b) (con't)

SOURCE	PROJECT	PROJECT NUMBER
Low Altitude Aircraft	Identification of Hazardous Waste Disposal Sites	34*
	Integrated Pest Management Systems	35
	Crop Area Estimation	39
	Delimiting Areas of Virus Infection in Vineyards and Blueberry Fields	41

*Project utilized more than one source

Category Two-(b) (con't)

SOURCE	NUMBER OF PROJECTS	PERCENT
Landsat	7	11.9
Skylab	2	3.4
High Altitude Aircraft	21	35.6
Medium Altitude Aircraft	15	25.4
Low Altitude Aircraft	<u>14</u>	<u>23.7</u>
TOTAL	59	100.0

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Category Three: ALL OTHER FUNDING RECEIVED

A. Non-NASA Funding by Year

YEAR	AMOUNT
1973	\$ 4,295
1974	25,000
1975	10,000
1976	18,221
1977	86,011
1978	191,513
1979	336,626
1980	293,558
1981 (to date)	<u>160,502</u>
TOTAL	\$1,125,726

B. Non-NASA Funding by Agency

SOURCE	NUMBER OF CONTRACTS	AMOUNT
Federal Agencies	10	\$ 750,812
State Agencies	13	140,621
Regional Agencies	4	18,949
County Agencies	4	9,026
Town-Local	3	584
Private	10	28,147
University	<u>N/A</u>	<u>177,587</u>
TOTAL	44	\$1,125,726

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Category Four: COMMERCIAL SPIN-OFFS FROM NASA FUNDED PROJECTS

SPIN-OFF	AGENCY	CONTRACTOR(S)	YEAR	NASA/MSU PROJECT NUMBER	COST
1. Lower Kalamazoo River Basin Land Cover/Use Inventory	Soil Conservation Service	MSU/CRS	1974	3	\$ 27,000
2. Acquisition of 1:36,000 CIR Photos (30,000 sq. km. area)	Michigan Department of State Highways and Transportation	Mark Hurd Aerial	1973	1,4	27,000
3. Acquisition of 1:31,680 CIR Photos (7,500 sq. km. area)	South Central Michigan Planning and Development Council of Region 3	Abrams Aerial Survey	1974	3	12,500
4. Forest Type Mapping of Four Counties	West Michigan Regional Planning Commission and Packaging Corporation of America	Environmental Sur- veys, Inc.	1975-77	8	35,000
5. Reproduction of Aerial Photos of Detroit Riverfront	15 Agencies	MSU/CRS	1975-76	18	300
6. Windsor Township Natural Resources Information System	Clinton-Eaton-Ingham Tri-County Regional Planning Commission	MSU/CRS	1976	25	980
7. Region V Land Cover/Use Inventory	Region V Planning and Development Commission	MSU/CRS, Bendix Aerospace Division	1977	24	21,000
8. Tri-County Natural Re- source Information Files	Clinton-Eaton-Ingham Tri-County Regional Planning Commission	MSU/CRS	1978	25	2,000

Category Four (con't)

SPIN-OFF	AGENCY	CONTRACTOR(S)	YEAR	NASA/MSU PROJECT NUMBER	COST
9. Inventory of Sand Mining Activities	Michigan Department of Natural Resources	MSU/CRS	1978-79	27	\$ 41,000
10. Inventory of Sand Dune Types	Michigan Department of Natural Resources	MSU/CRS	1978-79	27,23	42,240
11. Farmland Appraisal Maps	Eaton County Equilization Department	MSU/CRS	1978	22	3,580
12. Statewide Aerial Photography	Michigan Department of Natural Resources	Kucera and Asso- ciates	1977-78	8	309,000
13. Aerial Photos of Detroit Riverfront	Detroit Edison	MSU/CRS	1980	18	2,500
14. Acquisition of Aerial Photos	Various Agencies	RIA	1980-81	15,16,17,18, 19,26,35	17,000
15. Landsat Inventory for Pipeline Rating	Michigan Public Service Commission	MSU/CRS	1980	38	4,118
16. Landsat Forest Iden- tification	Michigan Department of Transportation	MSU/CRS	1981	37	<u>799</u>
			TOTAL		\$545,917

Category Five-(a): EDUCATIONAL ACTIVITIES

A. Conferences and Workshops

1. Conference on the Practical Applications of Remote Sensing in Michigan (1973)

This two-day conference brought together 85 representatives of Michigan agencies for a series of presentations and workshops on remote sensing.

2. Northwest Michigan Region Training Session (1974)

A two-day training session on color infrared photography and photointerpretation was given to 25 public officials from 8 counties in Michigan.

3. Michigan Land Cover/Use Classification System Workshop (1976)

A one-day workshop was held to familiarize personnel from 8 regional planning agencies with the Michigan Classification System and the various remote sensing inventory options available for preparing land cover/use maps.

4. Association of American Geographers' Special Session: Applied Remote Sensing (1977)

A session was organized for the 73rd AAG Meetings in Salt Lake City by Michigan State, which brought together speakers from three other Office of University Affairs Remote Sensing Projects to explain the thrust of activities in their particular states: Dr. Stan Morain of TAC, New Mexico was the discussant.

5. Cooperative Extension Service Workshops (1978)

Two one-day workshops on the sources, techniques and applications of remote sensing were given to 64 individuals from various agencies of 8 counties.

6. Conference on Applications of Cartography and Remote Sensing (1978)

A one-day conference was held to provide information on recent developments in both fields to 87 paid attendees from public agencies and private firms in Michigan.

7. Cooperative Extension Service Workshops (1979)

Four one-day workshops on the sources, techniques and applications of remote sensing were given to 156 individuals from various agencies of 30 counties.

8. Michigan Landscape Architecture Days Workshop (1979)

A one-day workshop on the sources, techniques and applications of remote sensing was given to 26 landscape architects.

9. Short Course in Remote Sensing for Forest Inventory (1980)

A three-day short course on the use of color-infrared photography for forest inventory was conducted for 20 professional foresters.

B. Major Technical Assistance and Briefing Activities

1. Red Cedar River Basin Watershed Plan Development (Soil Conservation Service and Michigan Department of Agriculture, 1973)
2. Northwest Michigan Resource Conservation and Development Project Land Resources Inventory Mapping Program (Soil Conservation Service, 1973)
3. Forest Plantation Classification and Inventory Program (Forest Service, 1973)
4. Huron Pines Resource Conservation and Development Project (Soil Conservation Service, 1973)
5. Northwest Michigan Economic Development District and Regional Planning Commission (Northwest Michigan Planning Commission, 1973)
6. Arcadia Power Plant Construction (Northwest Michigan Planning Commission, 1973)
7. Traverse Bay Residential Development Survey (Northwest Michigan Planning Commission, 1973)
8. High School Vocational Education Program Development (MSU Agriculture and Natural Resources Education Institute, 1973)
9. Land Planning Data Bank (West Michigan Regional Planning Commission, 1973-75)
10. Photographic Acquisition Assistance and Interpretive Training (Michigan Department of State Highways and Transportation, 1973-75)
11. Photographic Acquisition Assistance (South Central Michigan Planning and Development Council of Region 3, 1974)
12. Augusta Creek Drainage Analysis (Kellogg Biological Station, Michigan State University, 1974-75)
13. Evaluation of Proposed Utility Corridors (Michigan Public Service Commission, 1974)
14. Effects of Accelerated Erosion Control Measures (Michigan Department of Agriculture, 1974)
15. Antrim County Land Use Inventory (Antrim County Planning Department, 1974)

16. Evaluation of the Area Surrounding Houses for Sale (Roger Pavilik Realty, 1974)
17. Power Transmission Corridor Planning (Consumers Power Corporation, 1974)
18. Oil Exploration (Cities Service Oil Company, 1974-75)
19. Use of Remote Sensing for Soil Mapping (Soil Conservation Service, 1974)
20. Determination of House Counts in Antrim County (John R. Snell Engineers, Inc., 1975)
21. Lake Erie Coastal Wetlands Assessment (Bureau of Sport Fisheries & Wildlife, 1976)
22. Development of Benjamin Davies Park (City of Lansing Parks & Recreation Department, 1976)
23. Development of the Red Cedar Bike Path (City of Lansing Parks & Recreation Department, 1976)
24. Shoreline Recession Rate Determination and Wetlands Interpretation (Michigan Department of Natural Resources, 1977-78)
25. Frost Impact on Grape Vineyards in Berrien County (National Grape Cooperative Association, Inc. and MSU Departments of Agricultural Engineering and Horticulture, 1977-78)
26. Statewide Aerial Photography Project (Michigan Department of Natural Resources, 1977-78)
27. Forest Type Mapping of Barry County (Soil Conservation Service, 1978)
28. Michigan Land Cover/Use Classification System Slide/Tape Program (Michigan Department of Natural Resources, 1978)
29. Forest Type Mapping of Montmorency County (Soil Conservation District and Michigan Department of Natural Resources, 1979)
30. Forest Type Mapping of Otsego County (Soil Conservation District and Michigan Department of Natural Resources, 1979)
31. Wetlands Protection Legislation (The State Senate and the Michigan Department of Agriculture, 1979)
32. Acquisition of Small Format Aerial Photos of Research Plots (MSU Department of Entomology, Botany & Plant Pathology, and Crop and Soil Sciences, 1978-79)

33. Woodcock Habitat Mapping (MSU Department of Fisheries & Wildlife, 1979)
34. Identification of Pits, Ponds and Lagoons (Michigan Department of Public Health, 1979)
35. Community Development and City Planning (Design Michigan, 1979)
36. Aerial Photos in Support of Legal Cases (Law, Weathers, Richardson and Dutcher, 1979)
37. Michigan Resource Inventory Legislation (Michigan Department of Natural Resources, 1979)
38. Identification of Forage Crops and Other Lands Related to Apiary (Beehives) Locations (Michigan Bee Keepers Association and MSU Department of Entomology, 1979)
39. Forest Resource Inventory and Computer Mapping (Forest Management Division, Michigan Department of Natural Resources, 1979)
40. Topographic Sampling Procedures for Archeological Investigations of Extinct 19th Century Town Sites in Mississippi (MSU Museum and Department of Anthropology, 1979)
41. Use of Computer Programs for Landsat Digital Processing for Advanced Remote Sensing Course (MSU Department of Geography, 1981)
42. Diazo Enhancement of Landsat Images for Land Use Mapping of the Entire State (Michigan Department of State Highways and Transportation, 1981)
43. Light Aircraft Aerial Photography for Agricultural Monitoring (Barry County Cooperative Extension Service, 1981)
44. Michigan State NCIC Affiliate (Michigan State Mapping Committee, 1981)
45. Aerial Photography of the Lansing Flood of 1975 (Snell Environmental Group, 1981)
46. Remote Sensing in Support of State Forestry Programs (Forest Management Division, Michigan Department of Natural Resources, 1981)
47. Power Plant Siting Inventory (Consumer Power Company, 1981)
48. Mapping Forest Resources With the ZTS (Champion Timberlands, 1980)
49. Aerial Photography for Site Planning (MSU Department of Forestry, 1981)
50. Beaver Census Study (Wildlife Division, Michigan Department of Natural Resources, 1980)

51. Drain Tax Assessment Procedures (Ingham County Drain Commission, 1981)
52. Diazo Enhancement of Landsat Scenes from East Africa (MSU Department of Geography, 1981)

C. Major Educational Presentations and Materials

1. Users Guide to High Altitude Imagery of Michigan, published by the Remote Sensing Project, 1973.
2. Educational Self-Training Slide Modules, 1974-75:
 - a. "Basic Photo Interpretation"
 - b. "Basic Photo Measurements and Stereoscopic Viewing"
 - c. "Photo Interpretation in Forestry"
3. Guide to Aerial Imagery of Michigan, published by the MSU Agricultural Experiment Station, 1977.
4. "Window to the World" exhibit at Impression 5 Museum, 1978.
5. "Applications of Remote Sensing and Computer Information Systems to County-Level Programs," County Commissioners Day, MSU, 1979.
6. "Making Land Use Decisions and Tax Assessments via Remote Sensing," Michigan Northern Counties Association, 1979.
7. "Computer-Assisted Farmland Appraisal," Northern Michigan Equalization Directors Association, 1979.
8. Landsat digital software developed for use in the MSU Department of Geography's course in advanced remote sensing, 1981.

Category Five-(b): NUMBER OF "REMOTE SENSING" COURSES OFFERED ON CAMPUS
AND ENROLLMENTS

1. Geography 224: Remote Sensing--Airphoto Interpretation

Use of aerial photographs in the identification and interpretation of physical and cultural features of the terrestrial environment. Includes principles of photogrammetry and stresses application and practice.

Offered four terms per year/17 sections.

Annual enrollment 1980-81: 225 students.

2. Geography 424: Advanced Remote Sensing Techniques

Extraction, analysis and interpretation of information obtained from remote sensors including conventional, infrared and radar imagery. Introduction to stereo-plotting devices, stressing theories of remote sensing and applications.

Offered one term per year.

Annual enrollment 1980-81: 25 students.

Category Five-(c): NUMBER OF FACULTY AND RESEARCH ASSISTANTS INVOLVED
IN THE PROGRAM

1. 20 faculty-rank persons from 14 departments
 2. 5 full-time staff (3 research specialists, 1 administrative/Professional and 1 clerical/technical)
 3. 16 student research assistants (mostly half- to three-quarter time)
-

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Category Six: AGENCY CONTACTS

Federal Agencies

- + *U.S. Army Corps of Engineers
- + U.S. Department of Agriculture
 - *Agricultural Stabilization and Conservation Service
 - Economics, Statistic and Cooperative Services (formerly Economic Research Service)
 - *Forest Service
 - Office of International Development
 - Science and Education Administration
 - *Soil Conservation Service
- + U.S. Department of Commerce
- + *U.S. Department of Energy
- + U.S. Department of Interior
 - Bureau of Sports Fisheries and Wildlife
 - *EROS Data Center
 - *Geological Survey
- + U.S. Department of State
 - Agency for International Development
 - *Energy Clearing House
- + *Solar Energy Research Institute

State of Michigan Agencies

- + *Department of Agriculture
- + *Central Michigan University
- + *Department of Education
- + Department of Natural Resources
 - *Air Quality Division
 - *Forest Management Division
 - *Geological Survey Division
 - Inland Lakes Division
 - *Land Resource Programs Division
 - Environmental Services Division
 - Resource Recovery Division

Category Six (con't)

 Water Quality Division

*Wildlife Division

- + Department of State Highways and Transportation

*Environmental Liaison Section

Photogrammetry Section

- + Public Service Commission
- + Department of Management and Budget
- + The Michigan Senate
- + *Michigan State Mapping Committee
- + Department of Public Health
- + *Western Michigan University
- + *University of Michigan
- + Michigan State University
 - *Department of Geography
 - *Department of Crop and Soil Sciences
 - *Department of Entomology
 - *Department of Agricultural Economics
 - *School of Urban Planning and Landscape Architecture
 - *Lifelong Education Programs
 - *Cooperative Extension Service
 - *Department of Civil Engineering
 - *Department of Agricultural Engineering
 - *Department of Forestry
 - *Department of Park and Recreation
 - *Department of Resource Development
 - *Department of Geology
 - *Department of Botany and Plant Pathology
 - *Department of Anatomy

Regional Planning and Administrative Agencies

- + East Central Michigan Planning and Development Council
- + Northeast Michigan Council of Governments
- + *Northwest Michigan Prime Forestlands Identification Project
- + Northwest Michigan Regional Planning Commission
- + Region 2 Planning Commission

Category Six (con't)

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- + Region V Planning and Development Council
 - + South Central Michigan Planning and Development Council of Region 3
 - + Southeast Michigan Council of Governments
 - + Southwest Michigan Regional Planning Commission
 - + Traverse Bay Regional Planning Commission
 - + *Tri-County Regional Planning Commission
 - + *U.P. Prime Forestlands Identification Project
 - + West Michigan Regional Planning Commission
 - + West Michigan Shoreline Regional Planning Commission

County Agencies

- + Alpena County Equalization Department
- + Antrim County Planning Department
- + Berrien County Office of Prosecuting Attorney
- + Calhoun County Health Department
- + *Cass County Planning Commission
- + Charlevoix County Equalization Department
- + *Clinton County Planning Department
- + Eaton County Equalization Department
- + Genesee County Planning Commission
- + *Gogebic County Forestry Commission
- + Grand Traverse County Planning Commission
- + *Ingham County Drain Commission
- + Kent County Equalization Department
- + Mason County Soil Conservation District
- + Monroe County Planning Commission
- + Montmorency County Soil Conservation District
- + Otsego County Soil Conservation District
- + Osceola County Cooperative Extension Service
- + *Saginaw-Bay Mosquito Control Commission
- + Wayne County Planning Commission

Category Six (con't)

Town-Local Agencies

- + *AuSable Trails Environmental Center
- + Citizens Concerned About I-69
- + City of Lansing Parks and Recreation Department
- + City of Lansing Vector Control Section
- + Design Michigan
- + Grand Mere Association
- + Lakefield Township, Saginaw County
- + *Lansing Community College
- + Saginaw-Chippewa Indian Tribe
- + Sault Ste. Marie Tribe of Chippewa Indians
- + City of Mason, City Administrator and Planning Commission

Private Agencies

- + Abrams Aerial Survey, Inc.
- + Bendix Aerospace Systems Division
- + *Champion International Corporation
- + Cities Service Oil Company
- + Columbia Gas System Service Corporation
- + *Consumers Power Company
- + CRW Associates
- + *Detroit News
- + *Dow-Corning Corporation
- + Durkee Lake Club
- + *Earth Resources Data Analysis Systems, Inc.
- + *Environmental Research Institute of Michigan
- + *Hillsdale Educational Publishers
- + John R. Snell Engineers, Inc.
- + *Lansing Engineers Club
- + Law, Weathers, Richardson and Dutcher
- + Menasha Corporation
- + *Michigan Blueberry Growers Association
- + Morbark Industries, Inc.

Category Six (con't)

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- + National Grape Cooperative Association, Inc.
 - + *Packaging Corporation of America
 - + *Resource Information Associates, Inc.
 - + Richard Morris, Attorney-at-Law
 - + Roger Pavilik Realty
 - + S.D. Warren Co.
 - + *Snell Environmental Group
 - + *United Press International
 - + Wakely-Kushner Associates
 - + Wickes Agriculture
 - + William Brehm
 - + Wolverine Electric Cooperative

*Contacts during current reporting period

Category Seven: TRAFFIC TO THE CRS LABORATORY--An Approximation

"Traffic" is interpreted to mean any of the many possible inquiries for information, guidance, or simply interest. Contacts are made either by telephone or visiting in person.

1. Telephone Inquiries: Average 186/year.
 2. Personal Drop-Ins: Average 150/year.
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A p p e n d i x

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